2015 Spring Precipitation Outlook for Northern and Central New Mexico

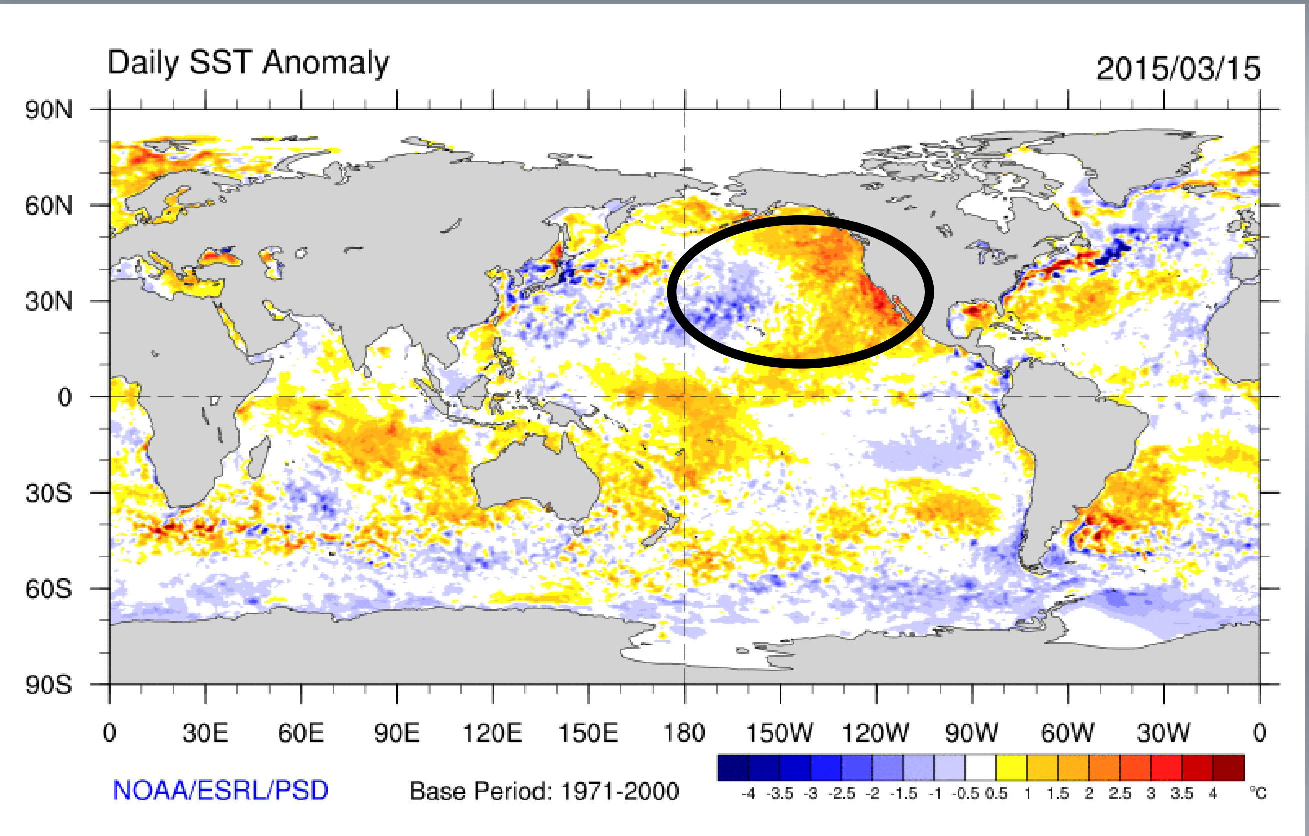


Figure 1. **December 2014, January and February 2015 Pacific Decadal Oscillation (PDO) index values were the highest December, January and February (DJF) values ever recorded (dating back to 1900) at 2.51 and 2.45, and 2.30 respectively.** The Sea Surface Temperature Anomaly (SSTA) scenario illustrated above is exceptional, depicting an exceptionally rare pattern for the period 1900 through present. 1941 was New Mexico's wettest year on record. Spring 2003 saw a mixed bag of wetter than average conditions in some areas but below average for others.

The development of a weak El Niño makes this Spring outlook slightly more straightforward. Extraordinarily, since 1900, the Sea Surface Temperature Anomaly (SSTA) scenario you see depicted above is highly infrequent. In the vast majority of instances when the Pacific Decadal Oscillation (PDO) was very warm as it is currently in early March 2015, the equatorial Eastern Pacific was typically rather warm and in at least a moderate El Niño state. What might the recent Sea Surface Temperature (SSTs) changes in the equatorial Pacific Ocean portend for Spring precipitation in New Mexico?

Pacific Decadal Oscillation (PDO)

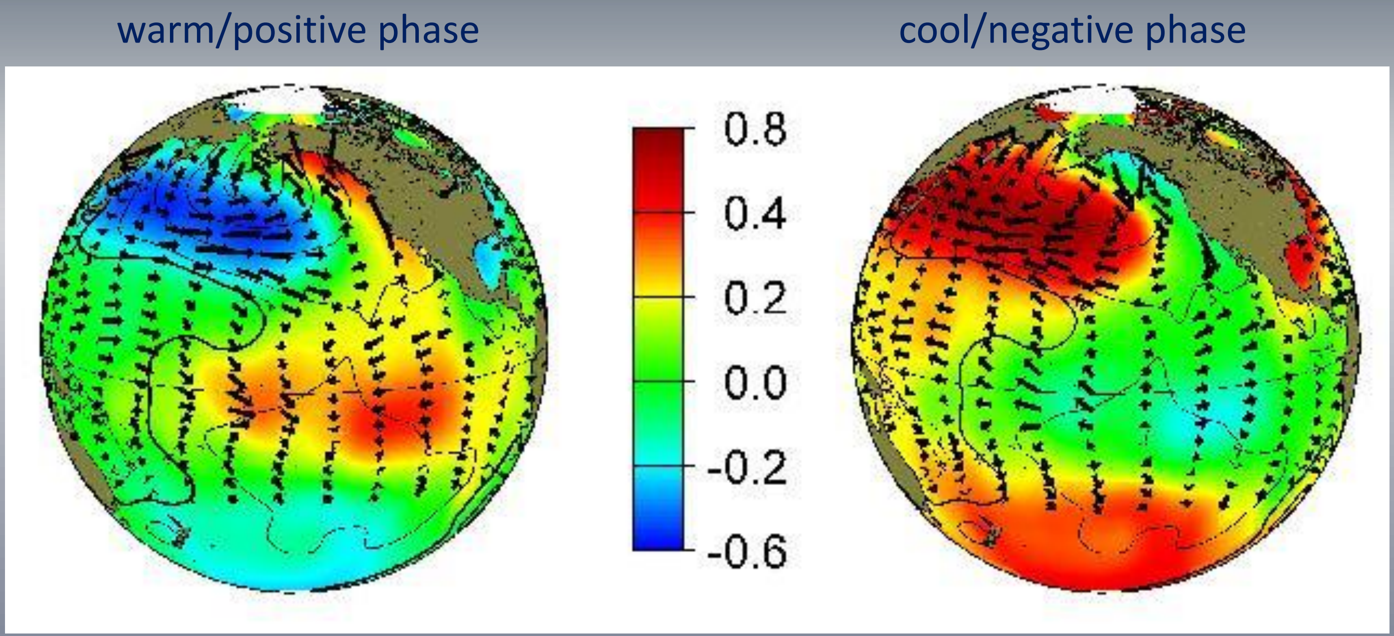
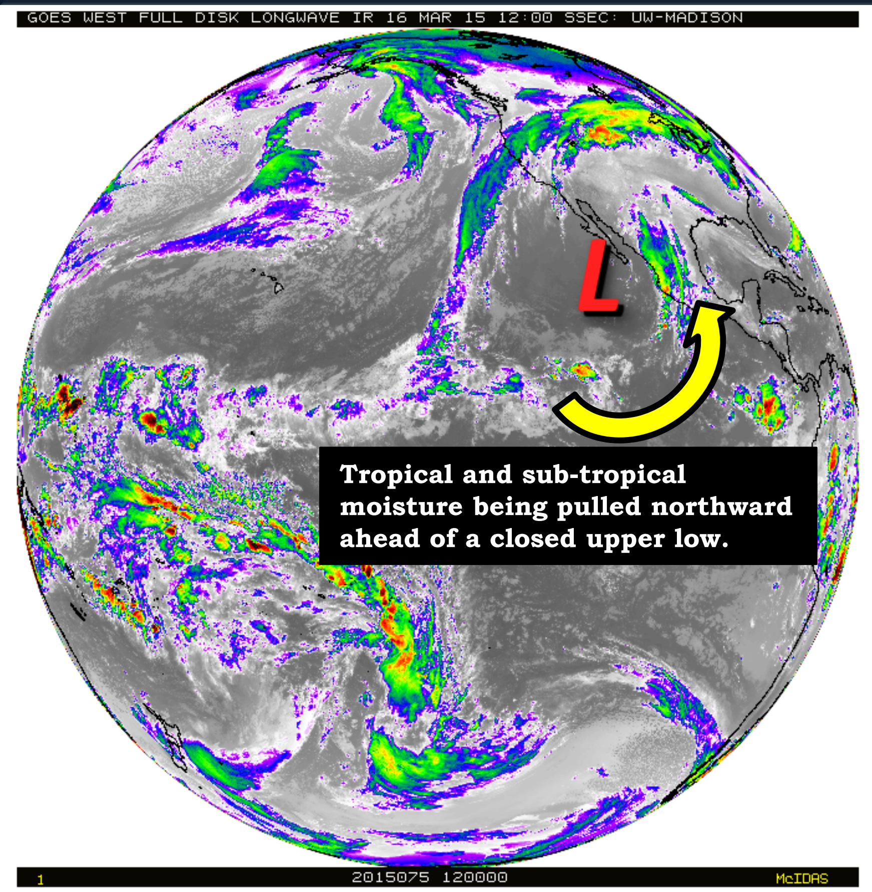


Figure 2. Typical wintertime Sea Surface Temperature Anomalies (colors), Sea Level Pressure (contours) and surface wind stress (arrows=force of wind on ocean surface) anomaly patterns during warm and cool phases of the Pacific Decadal Oscillation. The "Pacific Decadal Oscillation" (PDO) is a long-lived El Niño-like pattern of Pacific climate variability. While the two climate oscillations have similar spatial climate fingerprints, they have very different behavior in time. Two main characteristics distinguish the PDO from El Niño/Southern Oscillation (ENSO): first, 20th century PDO "events" persisted for 20-to-30 years, while typical ENSO events persisted for 6 to 18 months; second, the climatic fingerprints of the PDO are most visible in the North Pacific/North American sector, while secondary signatures exist in the tropics - the opposite is true for ENSO. *Source: Nate Mantua JISAO. For additional information regarding the PDO see: http://www.atmos.washington.edu/~mantua/REPORTS/PDO/pdo_paper.html*

How Does a Positive PDO Impact Weather/Climate in NM?



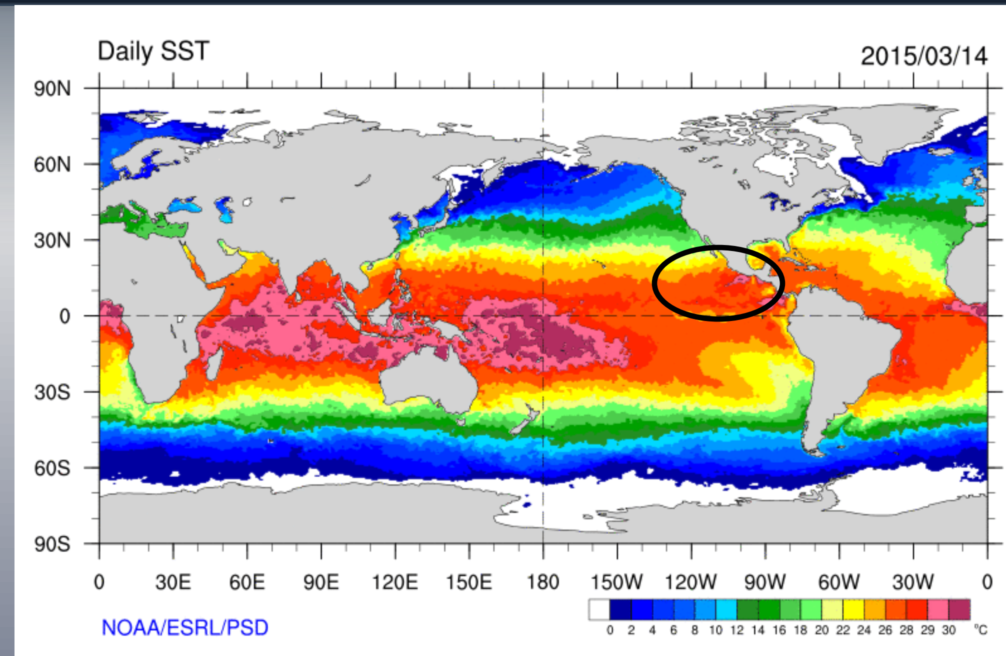


Figure 3. Global SSTs showing well above average temperatures along the southwest Mexican and Central American coasts. Closed upper lows often set up over/near the Baja but if SSTs are near or below average, the moisture flux from the ocean surface to the lower atmosphere is much less.

Figure 4. GOES-West Enhanced Infrared satellite image from 6:00 AM MDT 3/15/2015. Generally speaking, a positive PDO results in greater low level moisture availability from the far eastern Pacific Ocean along and near Baja California and the western Mexican coast.

PDO & MEI Values Since 1900

MEI relates ENSO events to six atmospheric variables in the tropical Pacific Ocean.

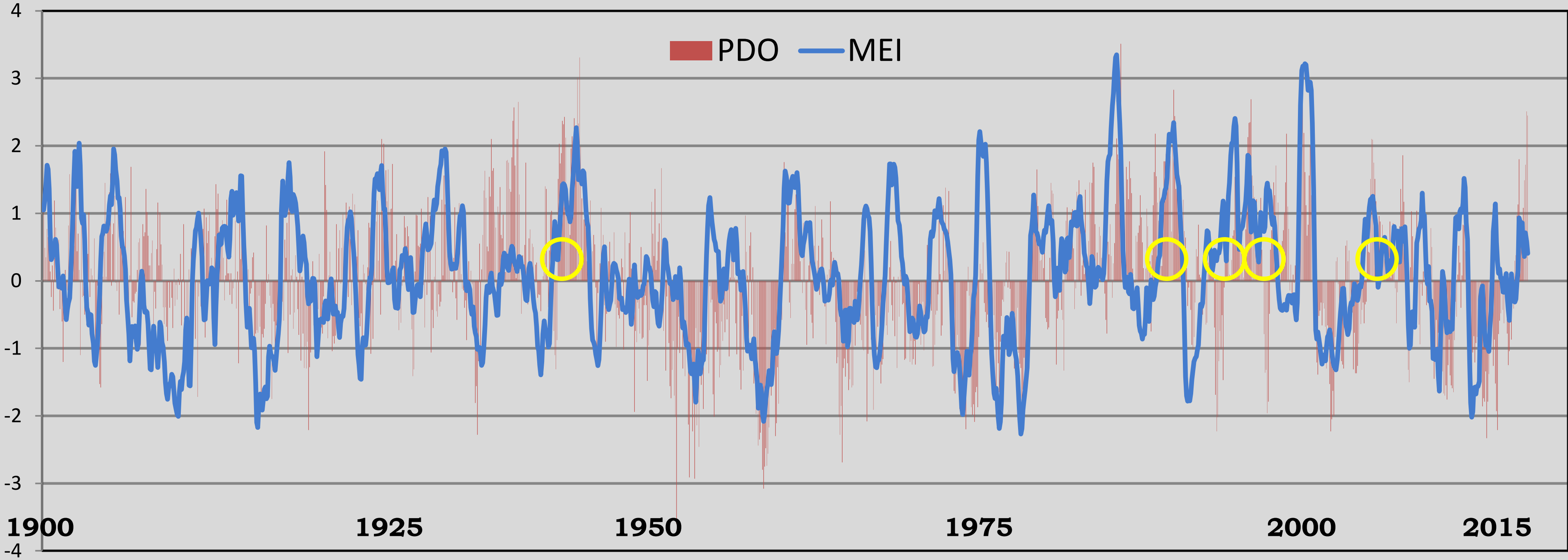


Figure 5. Monthly Pacific Decadal Oscillation (PDO) index and Multivariate ENSO Index (MEI) values from 1900-January 2015. The lack of a moderate El Niño with such a strong positive PDO value at this time of the year is very uncharacteristic of the Pacific Ocean. Unless conditions in the equatorial Pacific change rapidly, **which is not expected**, we are likely looking at rarely chartered territory for March, April and May (MAM) 2015. Since 1900, a highly positive PDO value and neutral or slightly cool conditions in the eastern Equatorial Pacific Ocean were extremely uncommon. Circled areas highlight analog years.

Analog Years

YEAR	PDO D/J/F	MEI D/J/F	ONI NDJ/DJF	AMO D/J/F
1940-41	1.96/2.14/2.07	0.967/1.35/1.55	N/A	-0.133/-0.057/0.100
1986-87	1.77/1.88/1.75	1.181/1.237/1.183	1.2/1.2	-0.350/-0.256/-0.196
1987-88	1.27/0.93/1.24	1.253/1.093/0.664	1.1/0.8	0.065/-0.020/-0.095
1993-94	1.07/1.21/0.59	0.565/0.340/0.191	0.1/0.1	-0.276/-0.279/-0.292
2002-03	2.10/2.09/1.75	1.114/1.185/0.923	1.3/1.1	0.022/0.068/0.005
2014-15	2.51/2.45/2.30	0.578/0.406/0.468	0.7/0.6	0.078/0.012/0.016

Figure 6. Looking back at more than 100 years of Pacific Decadal Oscillation (PDO), Multivariate ENSO Index (MEI), Oceanic Niño Index (not available prior to 1950) and Atlantic Multidecadal Oscillation values reveals five analog years when considering previous DJF SSTAs in the Pacific and Atlantic Oceans, 1940-41, 1986-87, 1987-88, 1993-94, and 2002-03. Several of these analog years when a weak to moderate were used based on recent developments in the equatorial Pacific and the expected strengthening of El Niño conditions during meteorological spring/MAM.

Snowfall – Analog Years vs. 30-yr Averages

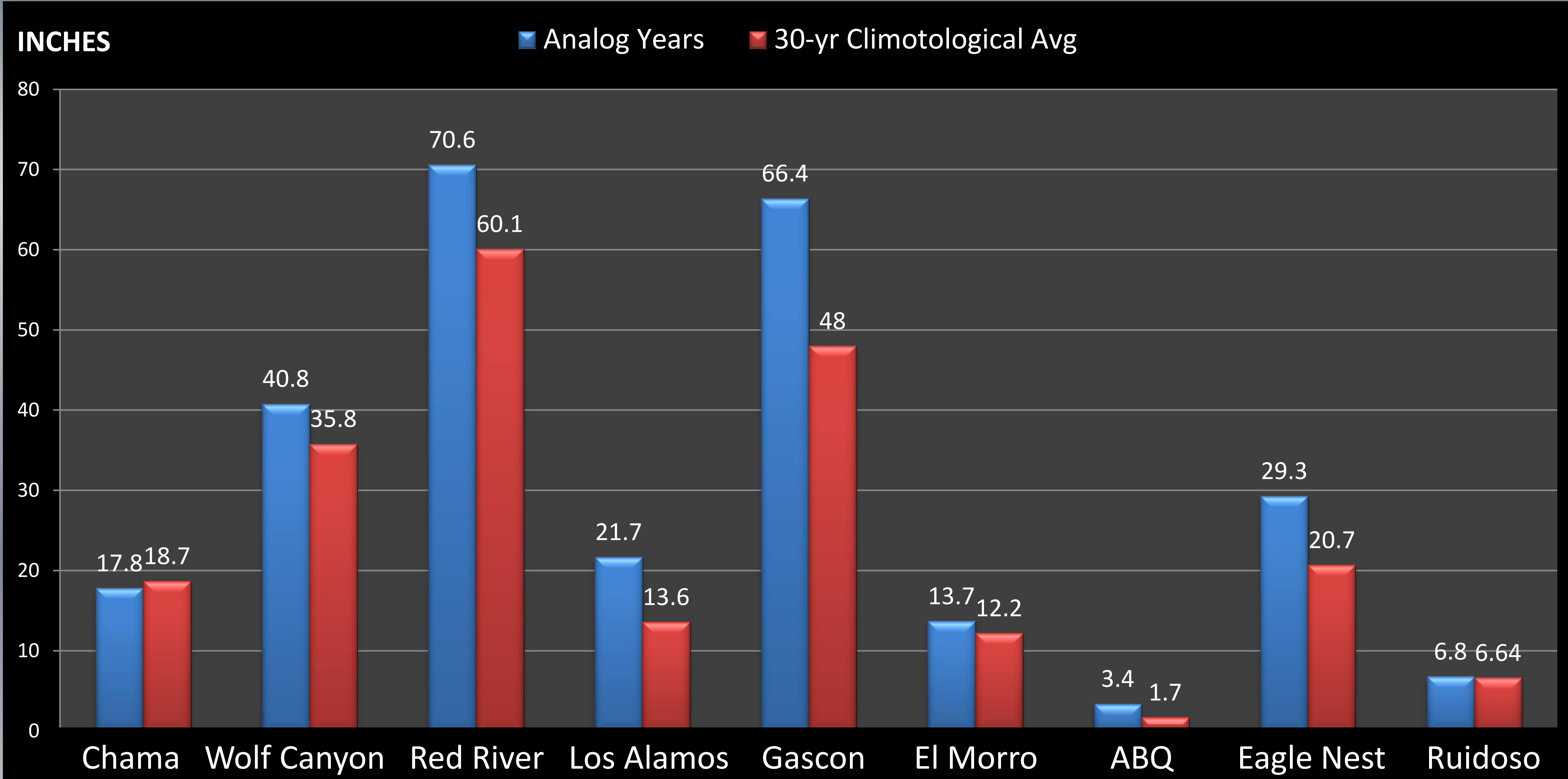


Figure 7. MAM snowfall in analog years (1940-41, 1986-87, 1987-88, 1993-94, and 2002-03) compared with 1981-2010 climatological averages. Eight of the nine sites had above average snowfall when averaging snowfall from the four analog years.

Precipitation – Analog Years vs. 30-yr Averages

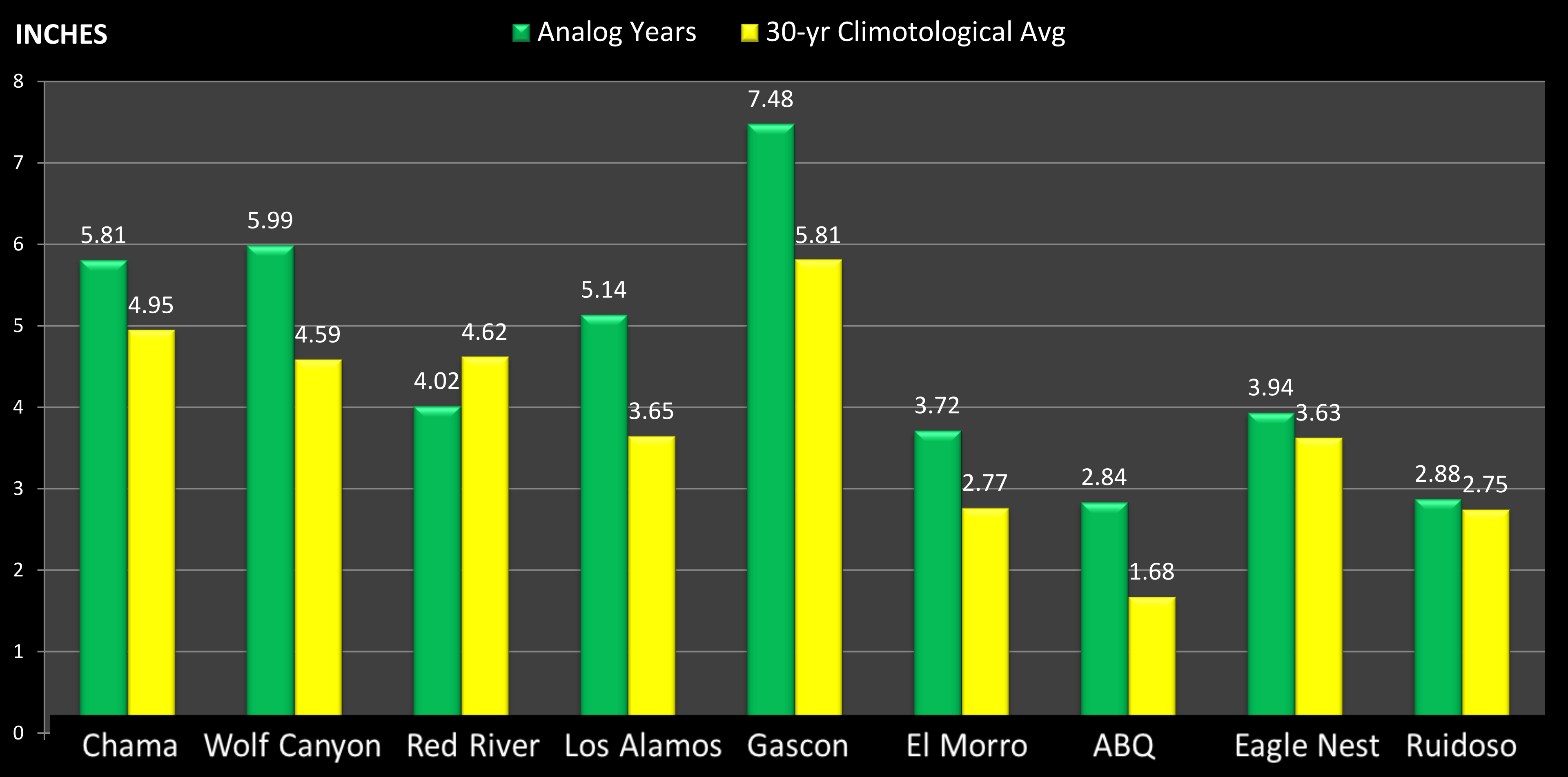


Figure 8. MAM precipitation in analog years (1940-41,1986-87, 1987-88, 1993-94, and 2002-03) compared with 1981-2010 climatological averages. Eight of nine sites were above average during analog years.

Analog Years' Precipitation and Temperature Anomalies vs. Climatology

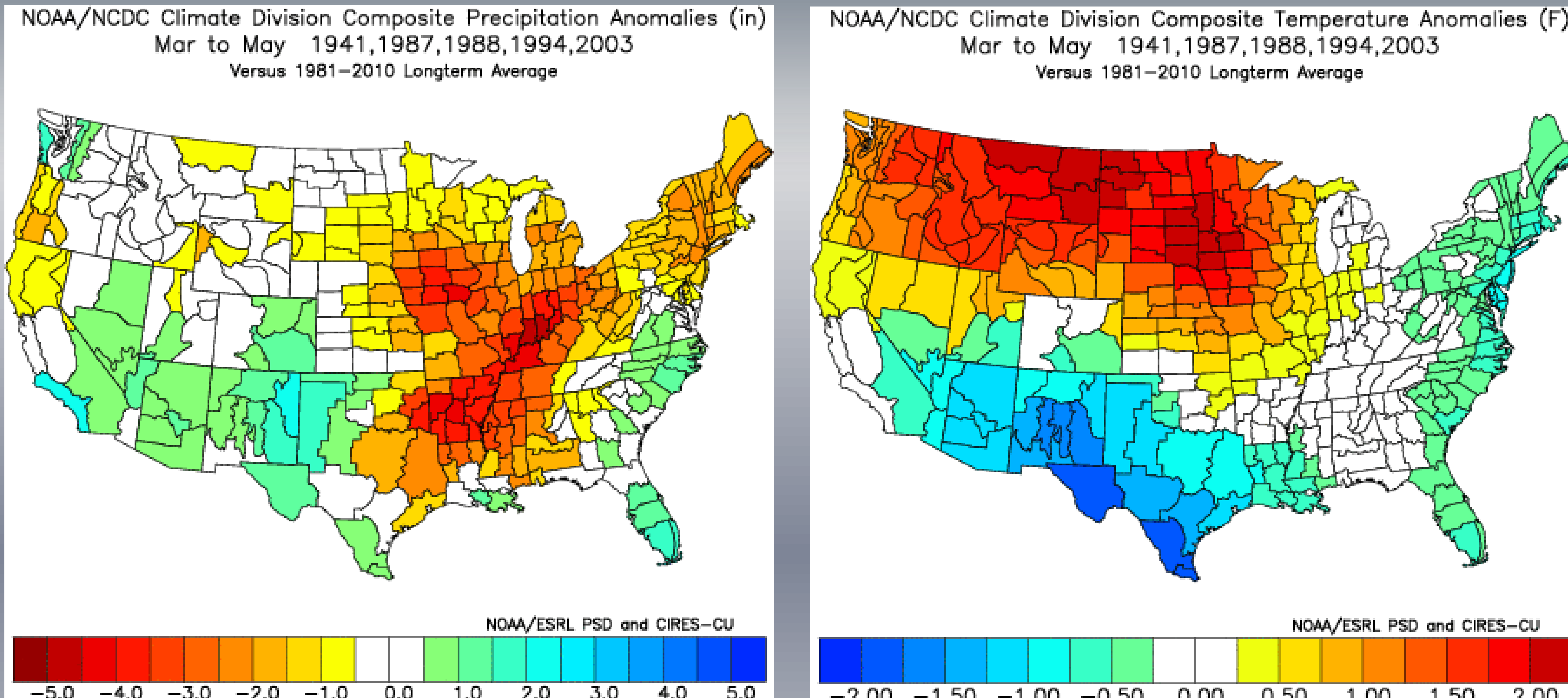
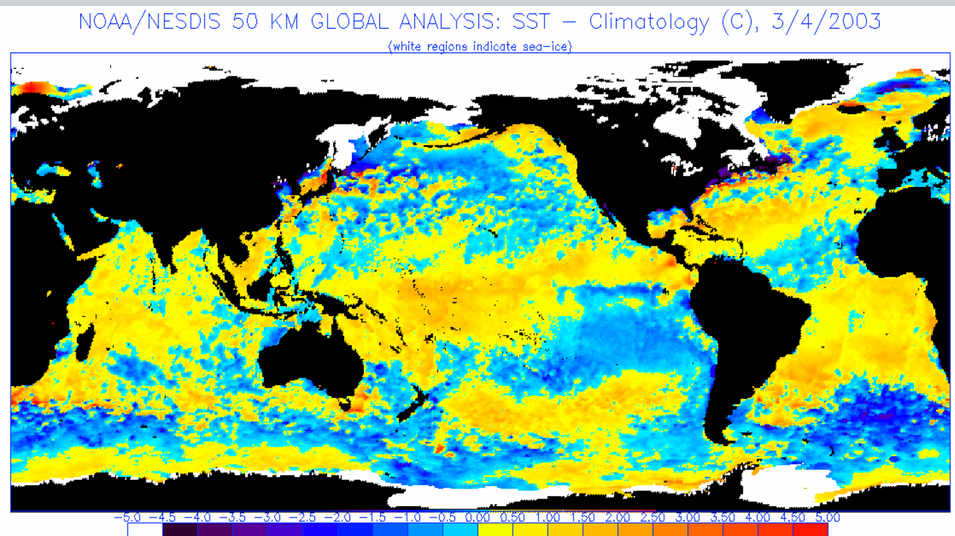


Figure 9. National Climate Data Center's climate division precipitation and temperature anomalies when compared with 1981-2010 climatology.

Comparing Early March 2015 SSTAs with Early March 2003



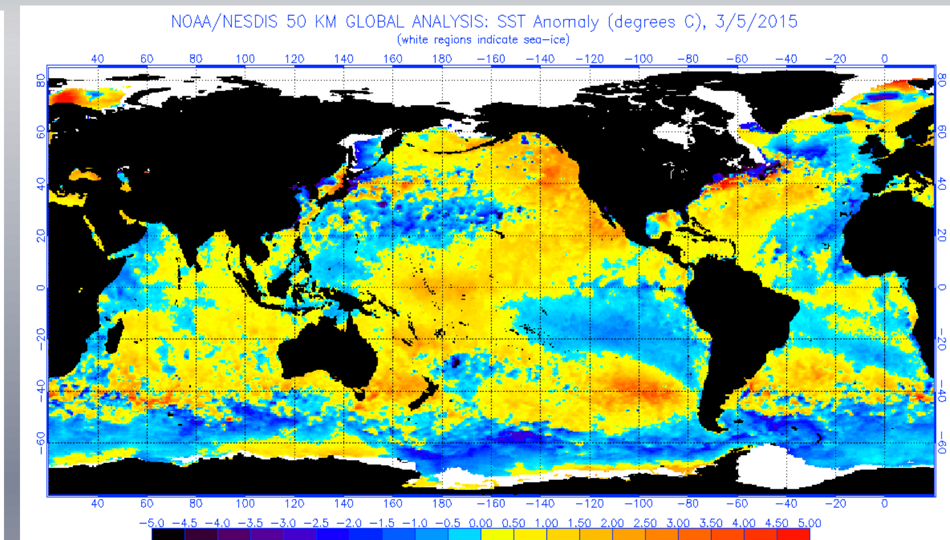


Figure 10. Sea Surface Temperature Anomalies from early March 2003 (left image) and March 2015 (right image). 2003 is the closest analog year/season to 2015. Note the warm anomalies along the west coast of North America signifying the strong positive PDO currently underway.

Latest Subsurface SSTA Data

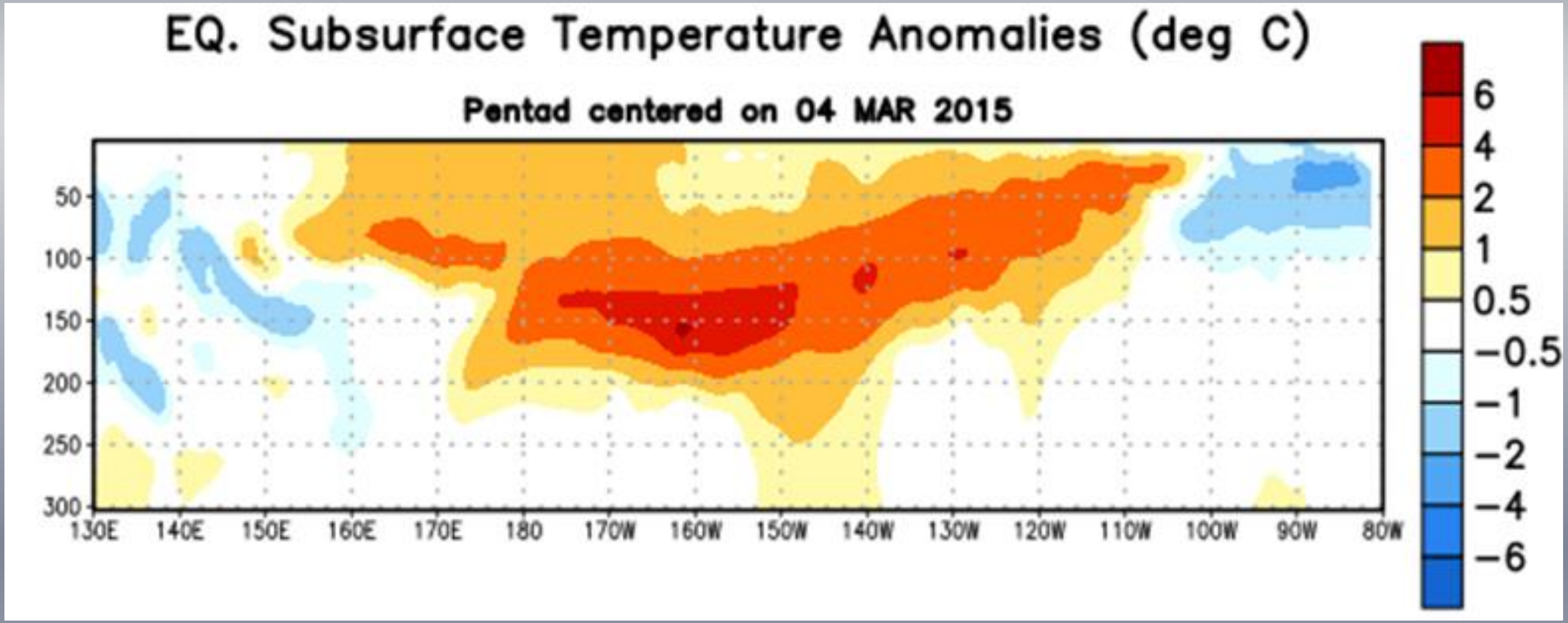


Figure 11. Warmer than average sub-surface waters have developed approximately 500 feet below the ocean's surface in the central Pacific Ocean as a result of the latest Kelvin wave travelling eastward through the Pacific Ocean. A Kelvin wave is a wave in the ocean or atmosphere that balances the Earth's Coriolis force against a topographic boundary such as a coastline, or a waveguide such as the equator.

Climate Prediction Center's Official MAM Outlook

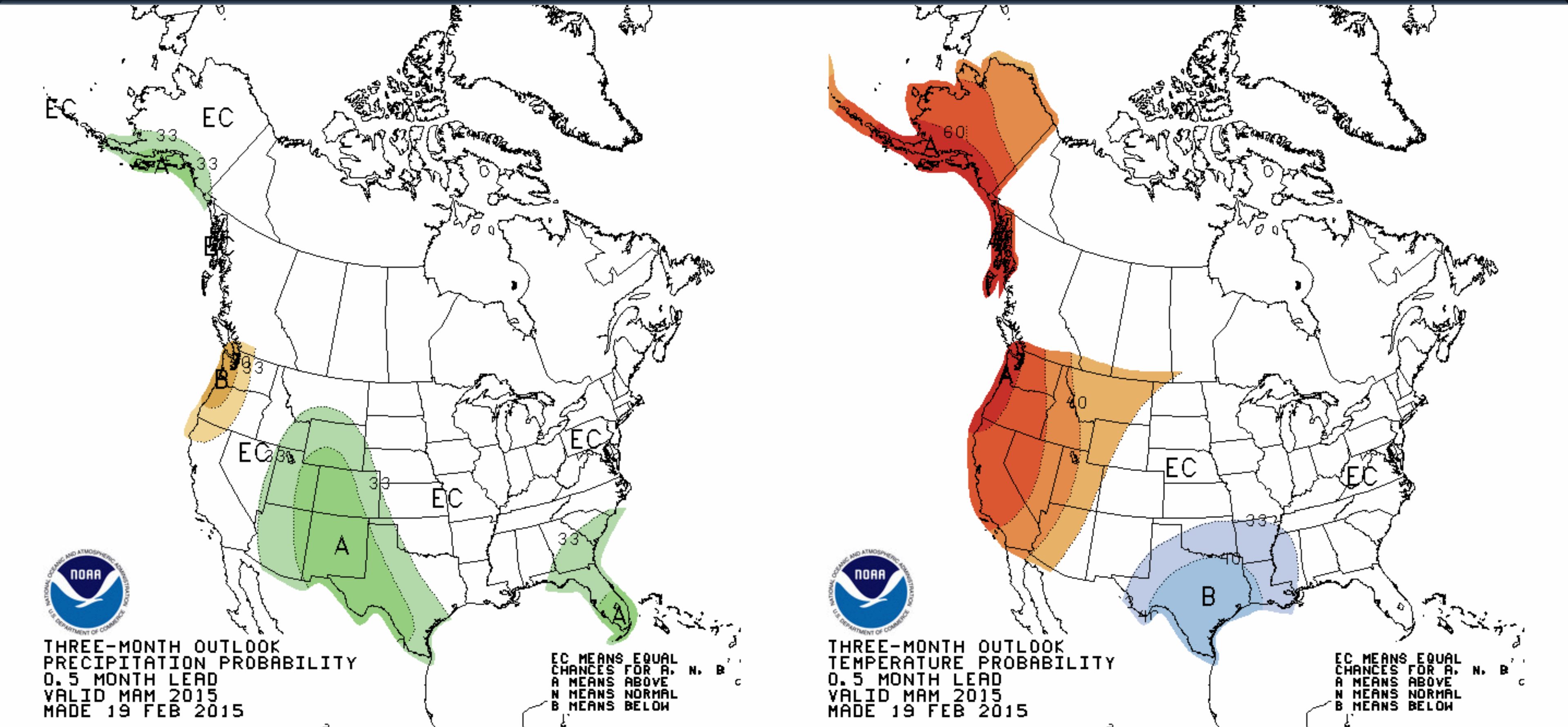


Figure 12. Climate Prediction Center's (CPC) official meteorological spring outlook. Above average precipitation for New Mexico is favored. Near average temperatures for New Mexico are favored.

Sea Surface Temperature Anomaly Forecasts for MAM

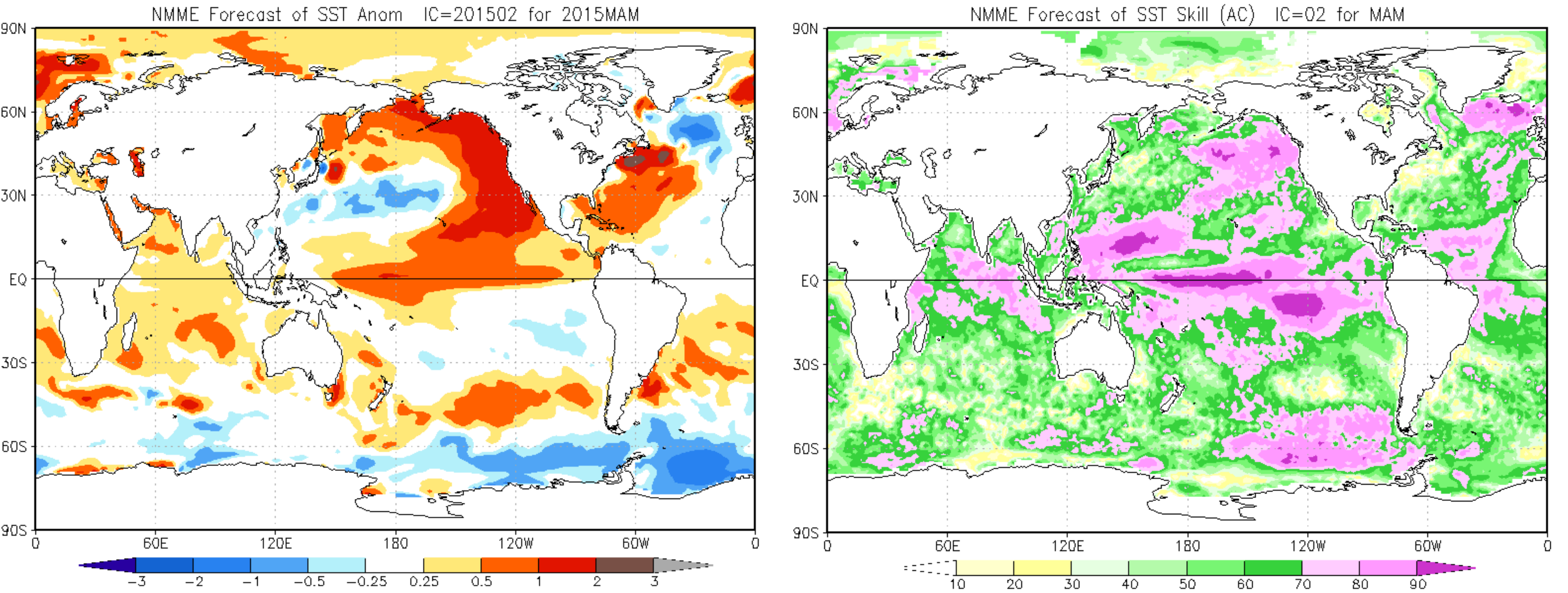
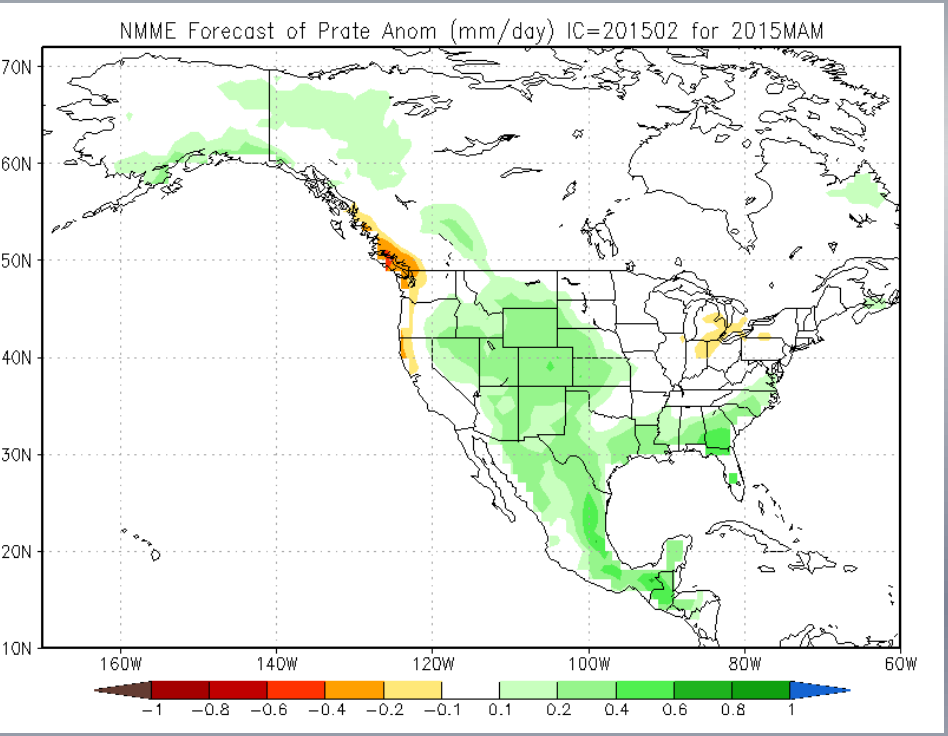


Figure 13. Sea Surface Temperature Anomaly (SSTA) Forecasts from the North American Multi-Model Ensemble (NMME) model (left image). Image on right depicts the NMME's skill score percentage. The NMME has the highest skill scores with regard to predicting SSTAs in the Pacific Ocean basin. NMME solution continues the unusually strong positive PDO (warm anomalies along the west coast of North America – orange color) along with warmer than average SSTs in the equatorial Pacific (positive ENSO or El Niño conditions).

The NMME

- The North American Multi-Model Ensemble (NMME) is an experimental multi-model seasonal forecasting system consisting of coupled models from US modeling centers including NOAA/NCEP, NOAA/GFDL, IRI, NCAR, NASA, and Canada's CMC.
- The need for the development of NMME operational predictive capability was recommended in the recent US National Academies report "Assessment of Intraseasonal to Interannual Climate Prediction and Predictability". The multi-model ensemble approach has proven extremely effective at quantifying prediction uncertainty due to uncertainty in model formulation, and has proven to produce better prediction quality (on average) than any single model ensemble. This multi-model approach is the basis for several international collaborative prediction research efforts, including an operational European system. There are numerous examples of how this multi-model ensemble approach yields superior forecasts compared to any single model[2].

NMME Model Prediction for Precipitation in MAM



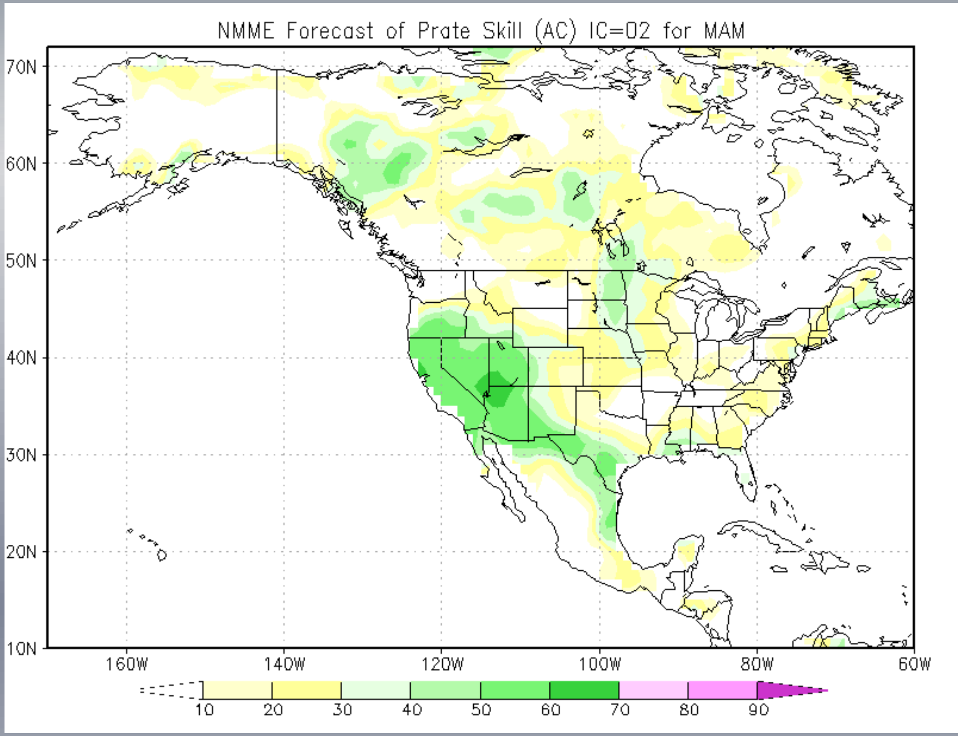
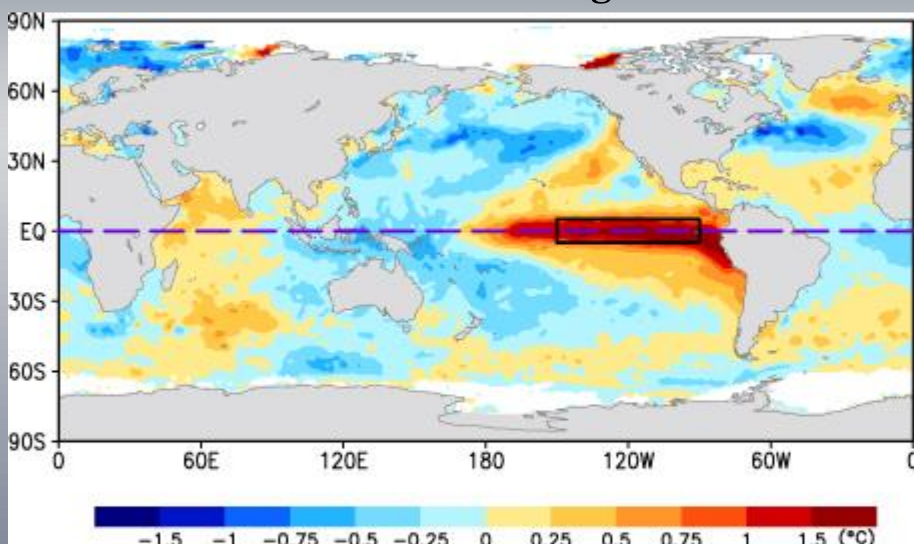


Figure 14. NMME precipitation rate anomaly forecast for MAM (left image). The model predicts greater than average precipitation for much of the Rockies and eastern Great Basin. Image on the right is the skill percentage score for the NMME. The NMME model has the highest skill score of all the coupled atmosphere-ocean models. Note however that its skill score is highest over Arizona, the Great Basin and California. Much of northeast New Mexico is less than 50% which indicates the model's skill is poor for the northeast two-thirds or so of New Mexico.

El Niño Modoki

Anomalous SSTs during El Niño



Anomalous SSTs during El Niño Modoki

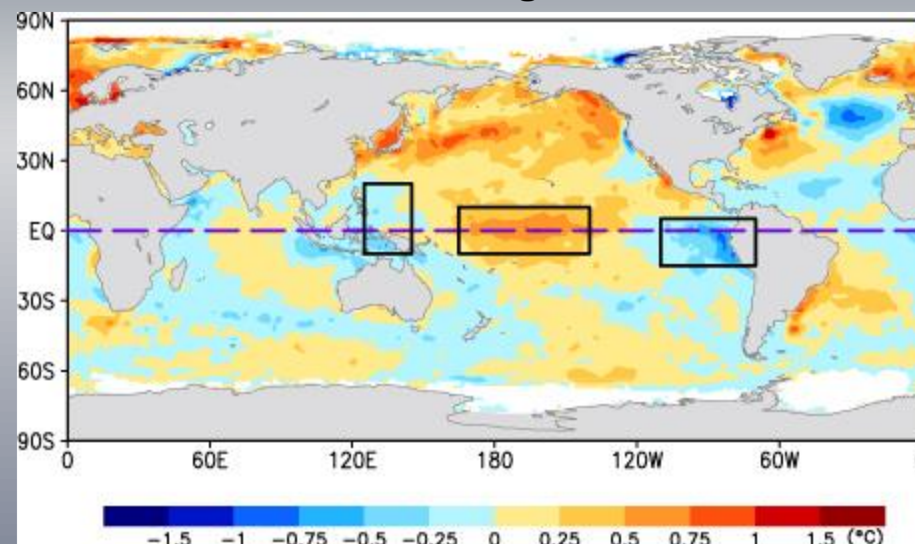
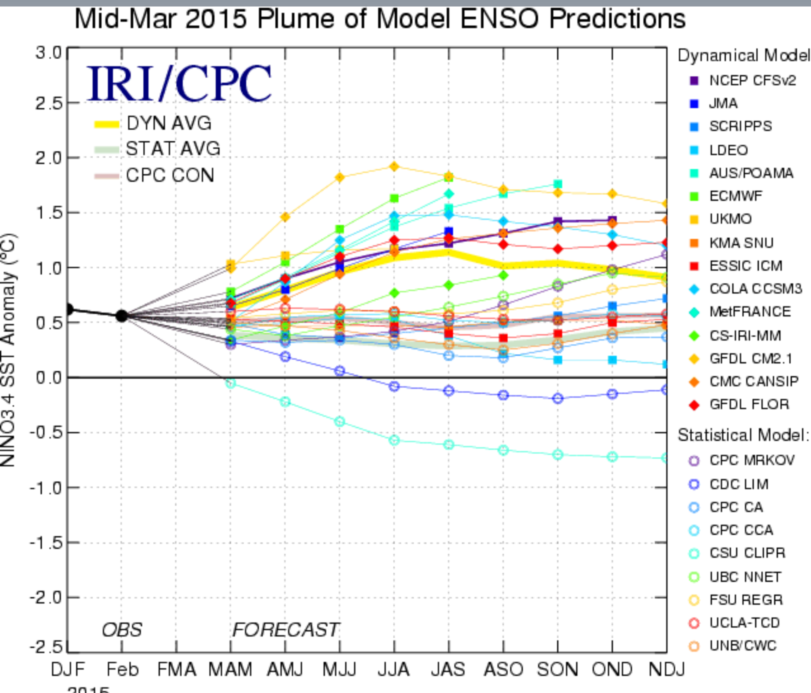


Figure 15. El Niño Modoki is a coupled ocean-atmosphere phenomenon in the tropical Pacific Ocean. It differs from a conventional El Niño, which is characterized by strong anomalous warming in the eastern equatorial Pacific (left image), in that strong anomalous warming is observed in the central tropical Pacific flanked by cooler-than-average SSTs in the eastern and western tropical Pacific (right image). Atmospheric teleconnections associated with El Niño Modoki are very different from the conventional El Niño. El Niño Modoki's generally result in precipitation anomalies over the western and southwestern United States that are similar to La Niña or the cold phase of ENSO[1]. The current pattern is more of the El Niño Modoki flavor. While this may be the case, current conditions and model forecasts for the equatorial Pacific in MAM do not reflect a definitive El Niño Modoki and in fact, indicate warmer waters will develop in the far eastern equatorial Pacific Ocean in MAM. Additionally, the well above average SSTs in the far eastern pacific associated with the strong PDO are expected to provide above average low and mid level moisture to the southwest United States.

Recent Developments in the Western Tropical Pacific



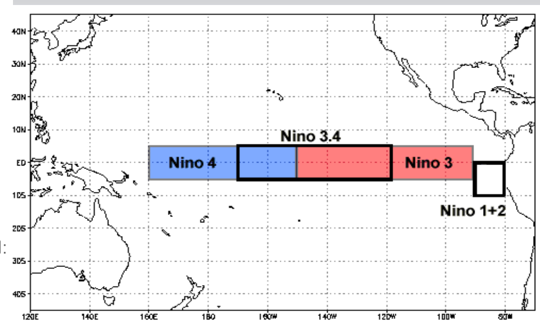


Figure 19. On March 16 at 01:35 UTC, the MODIS instrument aboard Aqua provided a visible image of the Tropical Cyclone Bavi moving through the Philippine Sea. Credit: NASA Goddard MODIS Rapid Response Team.

Figure 17 & 18. Latest Niño 3.4 SSTA predictions through the remainder of 2015 and the rectangular Niño regions. Dynamical models seemed to have picked up on the impacts from recent tropical cyclones in the southern hemisphere. The following is a description from the *Australian Bureau of Meteorology* on 3/17/2015: *In the western Pacific Ocean, severe tropical cyclone Pam and tropical storm Bavi straddled the equator, producing one of the strongest reversals in the trade winds in recent years. This change is expected to increase the already warm sub-surface temperatures currently observed in the tropical Pacific Ocean, which may in turn raise tropical Pacific Ocean surface temperatures in the coming months. However, it remains too early to say whether the reversal in the trade winds is a short term fluctuation or the beginning of a sustained trend.*

How About Wind?

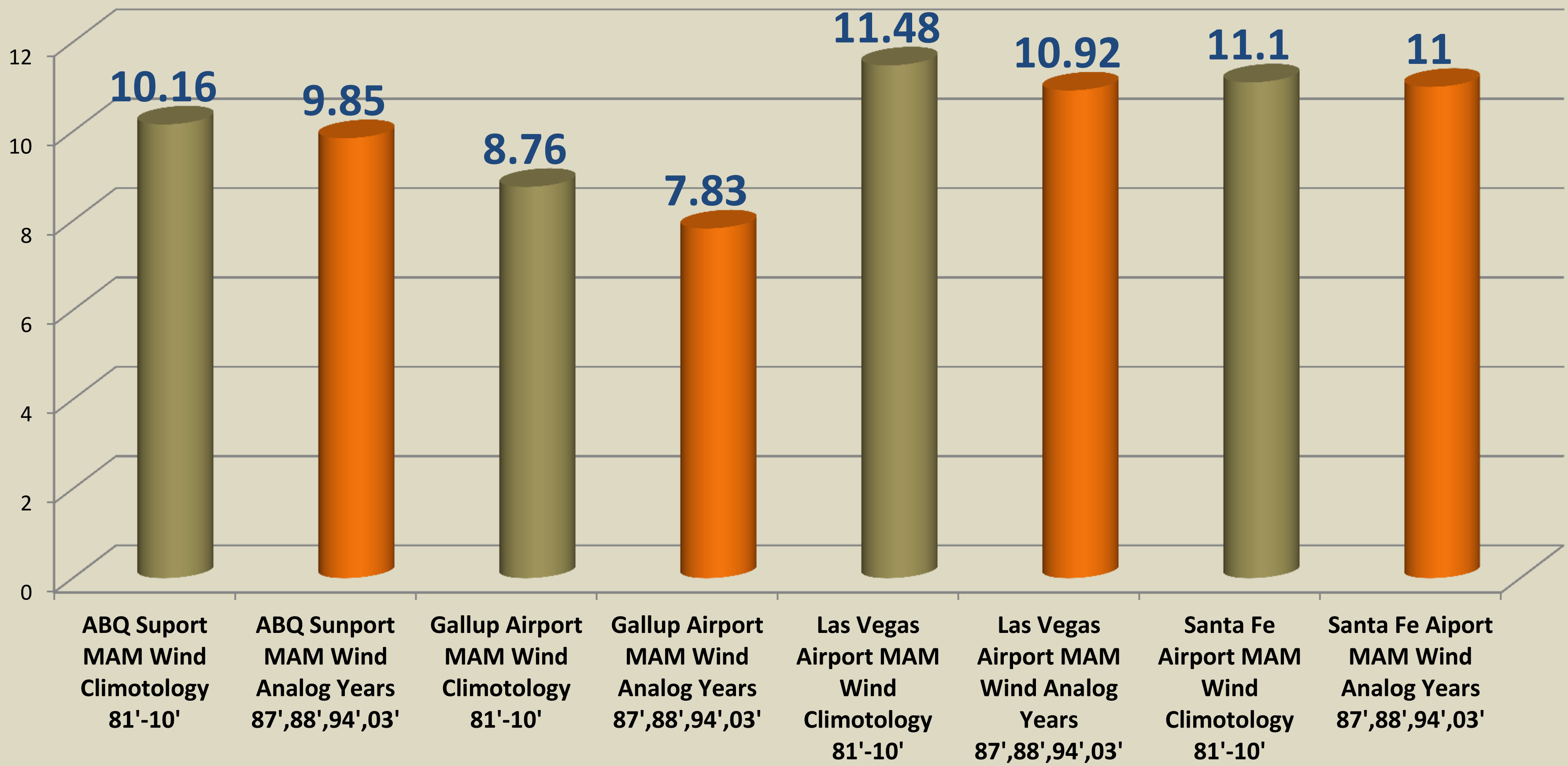


Figure 16. MAM hourly average winds during analog years were slightly below the 1981-2010 climatological averages for MAM. Spring will still be windy, but generally not as windy as compared to 30-year averages at the Albuquerque, Gallup, Las Vegas and Santa Fe airports. Of note, the first two weeks of March 2015 have been well below MAM climatology. As a result of the anticipated higher than average precipitation and lower than average wind speed, the frequency of high-impact dust storms should be lower as compared to Spring 2014.

Average Hourly MAM Winds

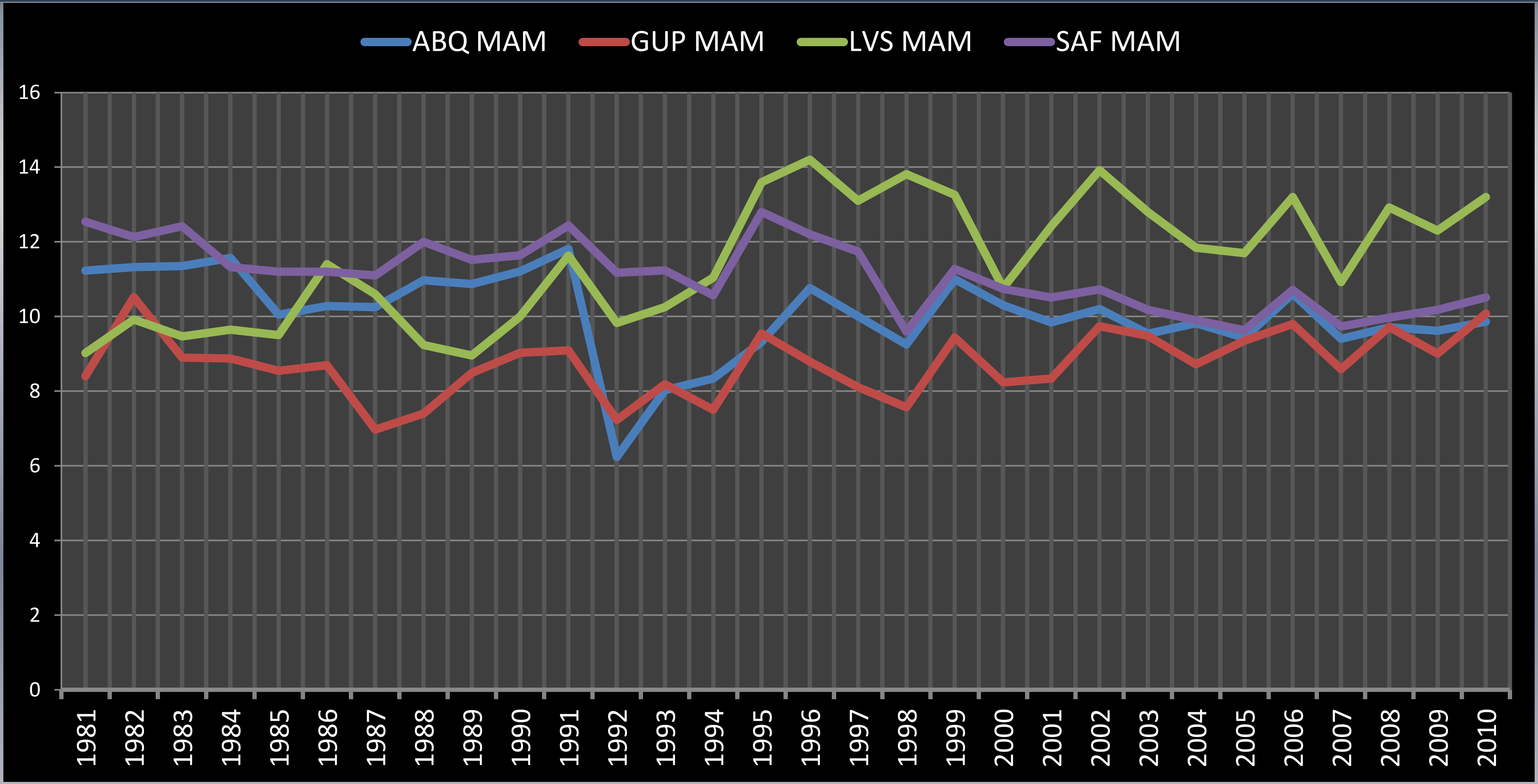


Figure 17. Average hourly sustained wind speeds in MAM from the Albuquerque International Sunport, Gallup Municipal Airport, Las Vegas Municipal Airport, and the Santa Fe Municipal Airport from 1981-2010.

Summary

- PDO Index values during December 2014, January and February 2015 were the highest on record (since 1900) for each month. Strong positive PDO Index values generally equate to more available low level moisture over the far east Pacific in the vicinity of Baja California and over the waters along and near the western Mexican coast.
- A weak El Niño has developed but it is more of the El Niño Modoki flavor where the core of above average SSTs are in the central Pacific Ocean. While this may be the case currently, recent SST trends and model forecasts for the equatorial Pacific Ocean in MAM do not reflect a definitive El Niño Modoki and in fact, the models predict significant warming in the eastern equatorial Pacific Ocean during MAM. Additionally, the well above average SSTs in the far eastern Pacific (strong PDO) will provide above average low and mid level moisture to the southwest United States.
- Increased tropical convection in the eastern tropical Pacific Ocean is expected to result in the breakdown of the upper level ridge along the west coast, allowing upper level Pacific troughs of low pressure to move eastward through central and southern California and the southwest United States.

Outlook

- Based on both the four analog years as well as forecasts from coupled atmospheric-oceanic numerical climate prediction models, the outlook for MAM snowfall is for <u>slightly above to above the 1981-2010 climatological average</u>.
- <u>With regard to precipitation, the outlook calls for above average amounts</u>. All nine sites during the four analog years experienced above average precipitation and the most skilled climate multi-ensemble model favors higher than average MAM precipitation for the northern two-thirds of New Mexico. Keep in mind, however, that the most skilled climate model has not performed well for the northeast two-thirds of New Mexico.
- For wind, <u>slightly below average wind speeds are anticipated</u> based upon the four analog years and the greater likelihood that the jet stream will split along/near the west Coast with the northern branch remaining north of New Mexico.

References

1. El Niño Modoki and its possible teleconnection. Ahsok et al 2007.

http://www.jamstec.go.jp/frsgc/research/d1/iod/publications/modoki-ashok.pdf

2. The North American Multimodel Ensemble. Kirtman et al. 2014.

http://www.cpc.ncep.noaa.gov/products/NMME/Kirtman_etal_2014.pdf

Outlook Information

- Outlook provided by National Weather Service Forecast Office Albuquerque, NM.

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